

Potential of Neem Leaf Powder as Bio-Adsorbents for Dye Colour Removal

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How to cite this paper: Thet Thet Wai | Ei Mon Aung | Nyein Chan Kyaw "Potential of Neem Leaf Powder as Bio-Adsorbents for Dye Colour Removal" Published in International

Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-3 | Issue-5, August 2019, pp.2502-2505,

<https://doi.org/10.31142/ijtsrd27987>



IJTSRD27987

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These toxic pollutants have to be treated both chemically and biologically before discharge into the surrounding areas. The removal of toxic substances from wastewaters has received increased attention to wastewater treatment technologists [1].

Thus, an eco-friendly biosorption process has become an area of research focus due to its biodegradability and non-toxicity. Biosorption is the uptake of chemical species from aqueous solutions onto biological materials via biological, physical and chemical mechanisms. The efficiency of biomaterials depends on factors such as the number of sites on the biosorbent material, their accessibility, chemical state, and the affinity between sites and target pollutants [2]. Different biomaterials can be used as adsorbents including but not the least agricultural wastes, fish scales, crab shells, chitin, seed husk, nutshells, eggshells, fruit pods, and fruit shells [3].

In removing impurities from effluents, as an absorbent, activated carbon is commonly used. Due to its expensive cost and the enormous amount of effluent produced by textile industries, researchers are exploring the use of alternatives, non-conventional low-cost adsorbents [4, 5]. Nowadays, most industries including plastic, paper, textile, and cosmetics use more and more synthetic dyes to color their products. Therefore, the development of new technologies for the removal of color from effluent is a necessary step in wastewater treatment process before disposal [6, 7].

ABSTRACT

In this study, two types of eco-friendly and low-cost bio-adsorbents, Neem leaf powder (NLP) and acid-treated Neem leaf powder (TNLP) were prepared for the removal of dye color from Congo red solution. The physicochemical parameters of the prepared adsorbents were measured. The structural features of these adsorbents were analyzed by FTIR, XRD, and SEM. These experiments were conducted with different process parameters such as adsorbent dosage and agitating time using batch adsorption method. Firstly, the dosage amount of adsorbents was optimized for constant shaking for one hour and it was observed that the maximum percent adsorption was found at 91% of 0.4 g for NLP and 76% of 0.4 g for TNLP. The optimum dosage amount of adsorbents, 0.4 g was selected for further study. After optimizing the adsorbent dosage, the optimum agitating time was observed at 60 min with the percent removal of 91% for NLP and 76% for TNLP. From this research, it was observed that NLP and TNLP can be used as bio-adsorbents to remove the color of the dye solution.

KEYWORDS: *Neem Leaf Powder, Adsorption, FTIR, XRD, SEM, Congo red*

INTRODUCTION

With the emergence of industries in Myanmar, more and more environmentally friendly systems of wastewater treatment are needed. Pollutants from these industries include dyes, heavy metals, and pharmaceuticals. They are very hazardous to the natural ecosystem and environments.

Neem trees are widely distributed throughout Myanmar and their leaves are easily available year-round. Therefore, in this study, Neem leaves are chosen to evaluate their potential in the removal of dye color from wastewater effluents.

MATERIALS AND METHODS

A. Materials

Neem leaves and Hydrochloric acid (HCl) were used in preparation of adsorbents; NLP (neem leaves powder) and TNLP (acid-treated neem leaves powder) and Congo red were used for the preparation of synthetic dye solution. Mature Neem leaves were collected from tall neem trees in the campus area of Mandalay Technological University. HCl and Congo red powder were obtained from the local market.

B. Preparation of Adsorbent Samples

In this experiment, two types of adsorbent were prepared; Neem leaf powder (NLP) and acid-treated Neem leaf powder (TNLP). Mature Neem leaves collected were washed repeatedly with water to remove dust and soluble impurities. The leaves were left in the sunlight for 3 days until they became dry and crisp. Then, the dried leaves were crushed into a fine powder in a mechanical grinder to obtain the Neem leaf powder (NLP). The NLP was sieved and the fraction (less than or equal to 75 μ m) were selected to use as an adsorbent. The selected fraction was again washed 8 times with water until the washed water is free of color and turbidity. Finally, washing was carried with distilled water. After which the NLP was dried

at 105°C in the air oven for about two hrs. The NLP was preserved in glass bottles for use as an adsorbent.

Another adsorbent (TNLP) was prepared by the following method. Firstly, the resulting NLP was treated with hydrochloric acid of 0.1 N. After that, the acid-treated NLP was activated by the furnace at 260°C for 25 minutes. And then, the activated NLP was washed until its pH value reached around 7. The adsorbent (TNLP) was obtained after removing the moisture from the activated NLP by drying.

C. Determination of Ash, Moisture and Organic Matter Content

The moisture content of the samples was determined by using Moisture Balance Ohaus (Model: MB 25). The ash content of the adsorbent samples was determined by placing the samples in a crucible and dried in a furnace. Firstly, the weight of the empty crucible was measured and recorded as W_a . A 10g NLP sample in a crucible, oven-dried at 105°C and stored in desiccator and the weight of crucible with sample was recorded as W_b . This W_b was introduced into the furnace and burnt at 600°C for 4 hour and final weight of crucible with the sample was recorded as W_c . The percentage of ash content was calculated by using (1).

$$\text{Ash content (\%)} = \frac{W_c - W_a}{W_b - W_a} \times 100 \quad (1)$$

The organic matter contents of the adsorbents were determined from the difference between 100% oven-dried adsorbent and the percentage of ash contents as illustrated in (2).

$$\text{Organic matter content (\%)} = 100 - (\% \text{ Ash Content}) \quad (2)$$

D. Characterization of Adsorbents

Adsorbents were analyzed and characterized by Fourier Transform Infrared Spectroscopy (FTIR), X-ray Diffraction (XRD), and Scanning Electron Microscope (SEM).

E. Adsorption Experiment

The Congo red dye powder was available from the local market. The synthetic dye solution was prepared with 70 mg of the Congo red dye powder which is dissolved in 1000 ml of distilled water. Firstly, to optimize the adsorbent dosage amount, various amount NLP and TNLP (0.1g, 0.2g, 0.3g, 0.4 g, and 0.5 g) are added to synthetic Congo red dye solution (50ml) and adsorption was carried out by stirring with constant agitation time. In this experiment, optimizing the dosage amount, agitation time was firstly adopted for 1 hr. To optimize the agitation time, adsorption experiment was carried out with optimum dosage of NLP and TNLP adsorbent and various time interval (30 min, 60 min, 90 min, 120 min, and 150 min). The solutions were agitated using magnetic stirrer, after which the samples were taken out and the supernatant solution was separated from the adsorbent by filtration with Whatman No. 41 filter paper. The filtrates were analyzed using UV-Vis spectrophotometer. The percentage of adsorption was carried out with (3).

$$\text{Adsorption (\%)} = \frac{C_o - C_e}{C_o} \times 100 \quad (3)$$

Where; C_o = Initial concentration (mg/L),

C_e = Final concentration (mg/L)

RESULTS AND DISCUSSION

Table 1 showed the physicochemical parameters of neem leaf powder bio-adsorbent.

Table I. Physicochemical Properties of Neem Leaf Powder

Parameters	Raw Sample
Moisture (%)	9.01
Dry matter (%)	90.99
Ash Content (%)	8.91
Organic Matter Contents	91.09
pH measurement	
(i) Raw	6
(ii) Carbonized	7.70

A. Characterization Analysis

FTIR spectra of the adsorbent (Fig. 1a- 1b) indicated the possible involvement of carbonyl ($-C=O$), carboxyl ($-COOH$) and hydroxyl ($-OH$) functional groups on the adsorbent's surface during the adsorption and interaction with a sulfonic acid group ($-SO_3Na$) on the dye molecules. According to the SEM micrographs of the neem leaf powder as shown in Fig. 2a and 2b, the powder was an assemblage of fine particles, which did not have regular, fixed shape and size. The surface appears as a fibrous material with irregular macropores and some expanded cavities which may allow for the diffusion of the dye molecules through the macropores of the adsorbent. As shown in Fig. 3a and 3b, XRD results indicate that the composition of the two adsorbents mainly includes C and O.

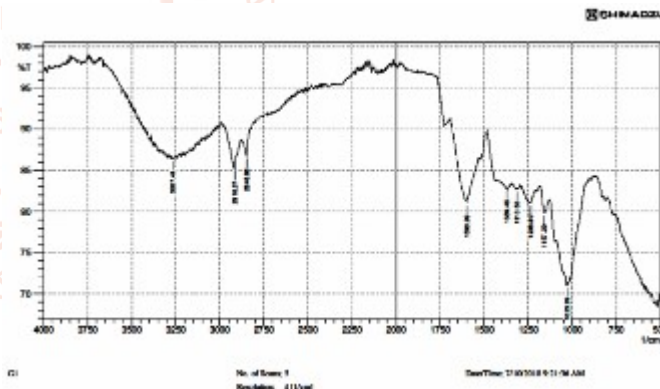


Fig.1a. FTIR Spectrum of NLP

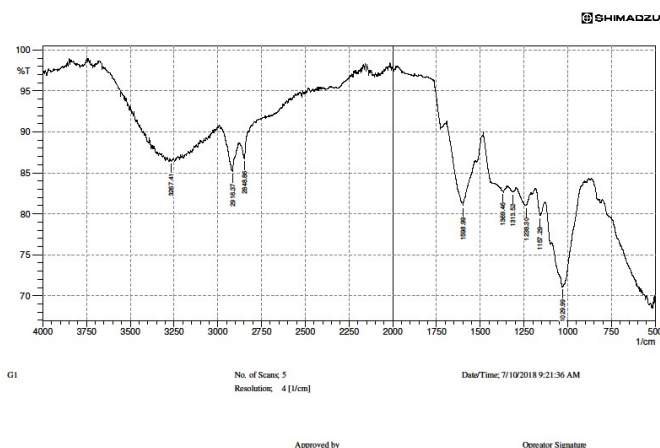


Fig.1b. FTIR Spectrum of TNLP

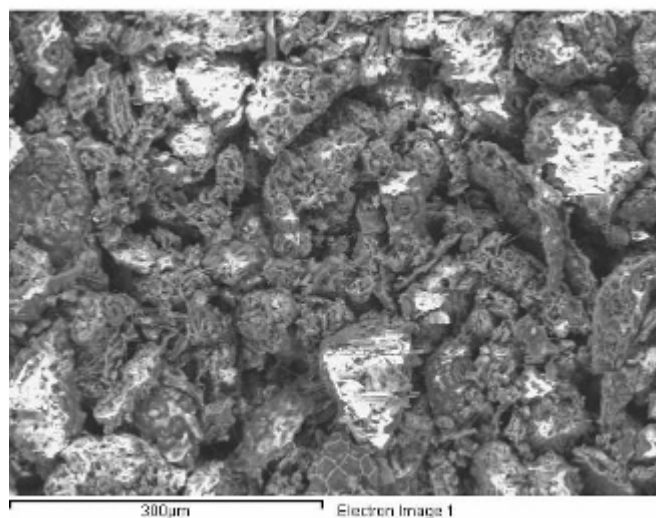


Fig.2a. SEM image of NLP

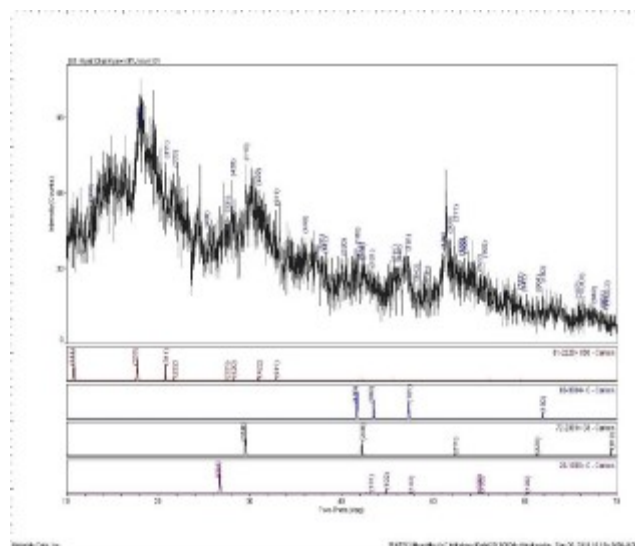


Fig.3a. XRD pattern of NLP

B. Factors affecting the rate of adsorption

The rate of adsorption was influenced by two factors; adsorbent dosage and agitation time.

Adsorption is performed in 50 ml of 0.0001 M of Congo red solution at various dosages of NLP and TNLP adsorbents (0.1 g, 0.2 g, 0.3 g, 0.4 g, and 0.5 g) by stirring at constant agitation for one hour and then settled for about one hour. After the adsorption process, the final solution is collected and measured with UV to get absorbance to observe the final concentration of the solution. After that, the percent of removals are calculated using (3). The results are shown in Fig. 4. It was resulted that the percent removal of NLP is 61% for 0.1 g, 73% for 0.2 g, 86% for 0.3 g, 91% for 0.4 g and 89% for 0.5 g. For TNLP, it was resulted that the percent removal is 47% for 0.1 g, 60% for 0.2 g, 61% for 0.3 g, 76% for 0.4 g and 71% for 0.5 g. According to the results, the optimum dosage was 0.4 g for both NLP and TNLP.

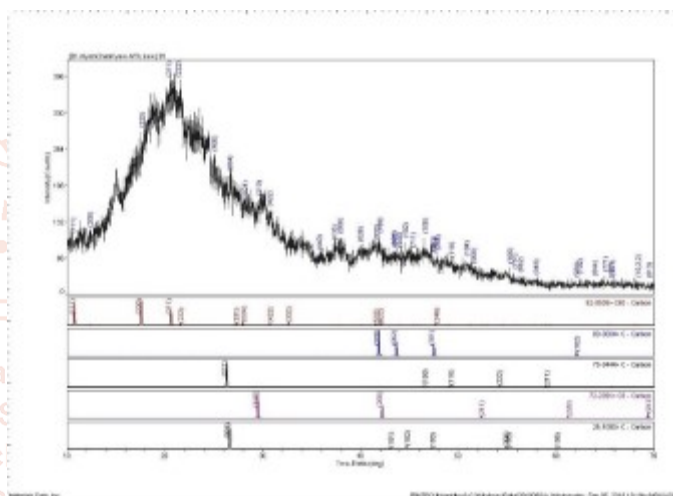


Fig.3b. XRD pattern of TNLP

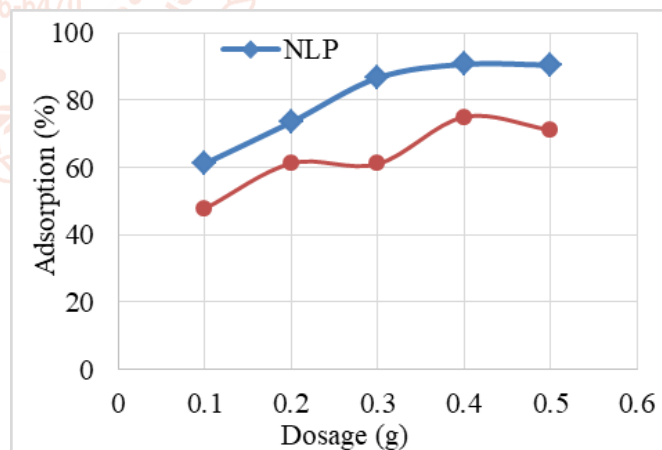


Fig.4. Variation of percent adsorption with adsorbent dosage

Fig.2b. SEM image of TNLP

To optimize the agitation time, adsorption was carried out for 30 min to 150 min with 0.4 g of adsorbents. After adsorption with different agitation time, it was found that the percent removal is 87% for 30 min, 91% for 60 min, 79% for 90 min, 86% for 120 min and 82% for 150 min for NLP. For TNLP, the percent removal is 63% for 30 min, 76% for 60 min, 74% for 90 min, 73% for 120 min, and 75% for 150 min. According to the results, as shown in Fig 5, the agitation time of 60 min was the maximum percent adsorption for both NLP and TNLP.

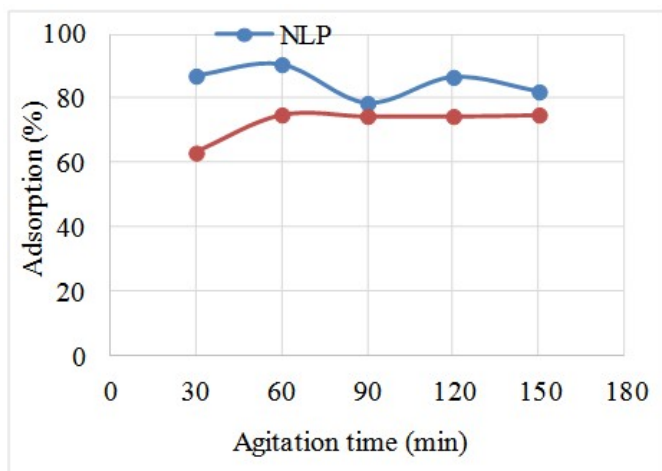


Fig.5. Variation of percent adsorption with agitation time

Conclusion

The research aimed to exploit the commonly available biomaterial Neem leaves for wastewater treatment. In this present work, two types of bio-adsorbents, the first NLP powder, and the second TNLP powders, were prepared. This NLP and activated TNLP were utilized for the adsorption of color from the prepared dye solution. They were used for the analysis of color removal with the different interval of dosage amounts to time in minutes. The efficiency of NLP was more than that of TNLP according to the resulting data. From these experiments, it can be concluded that NLP and TNLP can be used effectively to absorb the dye color. Thus,

there is a tremendous potential of Neem leaves to be explored as industrial low-cost effective bio-adsorbents.

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